Facility for Rare Isotope Beams

General Overview, Status – June 2017

FRIB

A Future Scientific User Facility

Michigan State University is establishing the Facility for Rare Isotope Beams (FRIB, pronounced F-RIB) as a scientific user facility for the Office of Nuclear Physics in the U.S. Department of Energy Office of Science (DOE-SC). FRIB is funded by the DOE-SC, MSU and the State of Michigan. Supporting the mission of the Office of Nuclear Physics in DOE-SC, FRIB will enable scientists to make discoveries about the properties of rare isotopes, nuclear astrophysics, fundamental interactions, and applications for society, including in medicine, homeland security, and industry.

The heart of FRIB is a high-power superconducting linear accelerator that accelerates heavy ions and produces rare isotopes by in-beam fragmentation. FRIB will enable scientific research with fast, stopped, and reaccelerated rare isotope beams, supporting a community of currently approximately 1,400 scientists from around the world.

Status

Civil construction of the FRIB conventional facilities—the tunnel for the linear accelerator and support buildings on the surface—began in March 2014, and the facility reached beneficial occupancy in March 2017. Technical construction—the construction of the equipment and infrastructure needed to make beam and conduct experiments—started in October 2014, and technical installation activities have escalated now that the beneficial occupancy stage of civil construction has been reached. Project completion is expected in 2022, managing to early completion in fiscal year 2021.

In August 2013, DOE-SC set the total cost for FRIB at $730 million. The State of Michigan has contributed $94.5 million of that cost. MSU's contribution beyond the total cost exceeds $212 million.

Science

The establishment of FRIB will support the mission of the DOE-SC Office of Nuclear Physics to discover, explore, and understand all forms of nuclear matter. Particle accelerators, including the superconducting linear accelerator at the core of FRIB, enable the production and study of rare isotopes no longer found on Earth that have a host of basic and applied uses.

Each element has a specific number of protons, its atomic number. Most elements are stable and can be found on Earth, like oxygen (8 protons), carbon (6 protons) or calcium (20 protons). When neutrons are added to or removed from the stable nucleus of an element, it becomes more unstable and will decay. While we are not sure exactly how many new isotopes remain to be discovered, it is pretty certain that a majority of isotopes have not been discovered. Many isotopes exist for only fractions of seconds before they decay towards stability. Rare isotopes are not normally found on Earth. Instead, they are forged in some of the most spectacular processes in the cosmos, including exploding stars known as supernovae.

How It Works

A beam of stable atomic nuclei is accelerated to half the speed of light and impinges on a thin

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target material. When the beam impacts the target, the resulting collision creates a number of reaction products, most with fewer protons and neutrons than the stable beam. (On occasion a beam nucleus picks up a proton or neutron from the target material.) Among those products are the rare isotopes requested by experimenters. This mixture continues to speed through the fragment separator, where a series of magnets selects the desired isotopes for study and sends them to the experimental area. There scientists use detectors to measure their unique properties or interaction with other nuclei.

Why It's Important

With FRIB we will, for the first time, have the capability to produce most of the same rare isotopes that are created in the cosmos, which then decay into the elements found on Earth. This will help us understand the origins of the elements. The same isotopes are needed to develop a predictive model of atomic nuclei and how they interact.

Researchers using FRIB will be able to improve our understanding of how atomic nuclei may be used to diagnose and cure diseases. Improved nuclear models and precision data will allow optimization of the next generation of nuclear reactors and evaluation of techniques to destroy nuclear waste. They will probe advanced materials to examine the processes involved on the nano- and micro-scale, providing insights into how materials are affected by radiation and other forces. Modeling atomic nuclei and their interactions—a challenging problem in science—can also help lead to breakthroughs in energy, security, medicine, the environment, and more.

Scientific Users

Approximately 1,400 users are engaged and ready for science at FRIB. They organized themselves in an independent FRIB Users Organization, with 19 working groups specializing in instruments and scientific topics. Members are from 113 U.S. colleges and universities, 12 national laboratories and 51 countries.

Education

Education of the next generation of scientists is a top priority. FRIB will build on MSU's practice to routinely involve undergraduate and graduate students in research. FRIB will expand those opportunities. MSU's nuclear physics graduate program is ranked No. 1 in the nation, according to *U.S. News and World Report's* rankings of graduate schools, and each year about 10 percent of the nation's nuclear science PhD holders are educated at MSU.

Department of Energy Office of Science

FRIB is supported by the Office of Science of the U.S. Department of Energy. The Office of Science is the single largest supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time. For more information, please visit science.energy.gov.

FRIB Resources

FRIB Project website: www.frib.msu.edu

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FRIB Users Organization: www.fribusers.org